

AMENDMENTS TO THE CLAIMS

The following listing of claims will replace all prior versions and listings of claims in the application.

LISTING OF CLAIMS

1. (previously presented) A boiling cooler for cooling a heating element, the boiling cooler comprising:

a refrigerant vessel storing liquid refrigerant therein, the refrigerant vessel having a boiling portion where the liquid refrigerant boils to produce refrigerant vapor, and defining therein a vapor outflow passage through which the refrigerant vapor flows toward first and second outlet portions provided at opposite ends of the vapor outflow passage;

a first radiator disposed at a first end side of the refrigerant vessel to communicate with the first outlet portion of the vapor outflow passage; and

a second radiator disposed at a second end side of the refrigerant vessel, opposite to the first side, to communicate with the second outlet portion of the vapor outflow passage, wherein:

each of the first and second radiators includes a heat exchange part having a vapor passage in which the refrigerant vapor from the vapor outflow passage flows to perform heat exchange with liquid coolant, and a tank defining a refrigerant chamber that communicates with the refrigerant vessel and stores therein the liquid refrigerant with a liquid surface;

the vapor passage of the heat exchange part is provided above the liquid surface stored in the tank; and

the vapor outflow passage is provided in the refrigerant vessel to extend in a direction crossing with a vertical direction.

2. (previously presented) The boiling cooler according to claim 1, wherein the heat exchange part further comprises a coolant passage in which the liquid coolant flows to perform the heat exchange with the refrigerant vapor, the coolant passage adjoining the vapor passage.

3. (cancelled)

4. (withdrawn) The boiling cooler according to claim 1, wherein the tank is separated from the coolant passage by a boundary wall that has a convexo-concave shape.

5. (withdrawn) The boiling cooler according to claim 4, wherein the boundary wall has a plurality of protruding portions protruding into the coolant passage and having heights that have a maximum value generally at a central portion of the tank in a horizontal direction and decrease toward both sides of the tank in the horizontal direction.

6. (withdrawn) The boiling cooler according to claim 4, wherein:
the boundary wall has first and second protruding portions protruding into the coolant passage; and

an inner fin is disposed in the coolant passage between outer walls of the first and second protruding portions to increase a radiation area for radiating heat.

7. (previously presented) The boiling cooler according to claim 2, further comprising a liquid coolant circuit composed of a cooling radiator and a pump for circulating the liquid coolant therein, wherein:

the coolant passage is connected to the liquid coolant circuit; and

the liquid coolant is circulated in the coolant passage by an operation of the pump.

8. (withdrawn) The boiling cooler according to claim 1, wherein the vapor outflow passage has an upper wall that is inclined so that the refrigerant vapor flows toward at least one of the first and second outlet portions upward along the upper wall.

9. (withdrawn) The boiling cooler according to claim 8, wherein the first radiator has a looped shape and surrounds an entire circumference of the refrigerant vessel where the vapor outflow passage is open to form the first outlet portion through which the first radiator and the vapor outflow passage communicate with each other.

10. (withdrawn) The boiling cooler according to claim 8, wherein:
the refrigerant vessel has a liquid return passage into which the condensate flows from the heat exchange part, the liquid return passage communicating with the vapor outflow passage through the tank of the first radiator.

11. (original) The boiling cooler according to claim 1, wherein the boiling cooler is used for a vehicle.

12. (cancelled)

13. (previously presented) The boiling cooler according to claim 1, wherein:
the tank communicates with the vapor outflow passage through the first outlet portion, and the heat exchange part disposed above the lower tank;
in the heat exchange part, the refrigerant vapor is liquefied as condensate by the heat exchange with the liquid coolant;
the refrigerant vessel has a liquid return passage into which the condensate flows from the heat exchange part, the liquid return passage communicating with the vapor outflow passage through the lower tank of the first radiator.

14. (withdrawn) The boiling cooler according to claim 1, further comprising:
a refrigerant flow control member disposed between the heat exchange part and the refrigerant vessel, and having a control plate that is disposed approximately horizontally to divide a radiator side space from a refrigerant vessel side space and has a plurality of communication ports through which the radiator side space communicates with the refrigerant vessel side space, the refrigerant flow control member being for controlling a flow of the refrigerant vapor from the refrigerant vessel

side space to the radiator side space, and a flow of the condensate from the radiator side space to the refrigerant vessel side space.

15. (withdrawn) The boiling cooler according to claim 14, wherein:

the plurality of communication ports are composed of a plurality of first communication ports and a plurality of second communication ports;

the plurality of first communication ports cylindrically protrude from an upper surface of the control plate into the radiator side space and are open at a position higher than the upper surface of the control plate in a vertical direction; and

the plurality of second communication ports cylindrically protrude from a lower surface of the control plate into the refrigerant vessel side space and are open at a position lower than the lower surface of the control plate in the vertical direction.

16. (withdrawn) The boiling cooler according to claim 15, wherein each of the plurality of first communication ports has an opening area larger than an opening area of each of the plurality of second communication ports.

17. (withdrawn) The boiling cooler according to claim 14, wherein:

the plurality of communication ports are composed of a plurality of first communication ports and a plurality of second communication ports;

the plurality of first communication ports are open on an upper surface of the control plate without protruding from the upper surface; and

the plurality of second communication ports cylindrically protrude from a lower surface of the control plate into the refrigerant vessel side space and are open at a position lower than the lower surface of the control plate in a vertical direction.

18. (withdrawn) The boiling cooler according to claim 17, wherein each of the plurality of first communication ports has an opening area larger than an opening area of each of the plurality of second communication ports.

19. (withdrawn) The boiling cooler according to claim 14, wherein:
the plurality of communication ports are composed of a plurality of first communication ports and a plurality of second communication ports;
the plurality of first communication ports cylindrically protrude from an upper surface of the control plate into the radiator side space and are open at a position higher than the upper surface of the control plate in a vertical direction; and
the plurality of second communication ports are open on a lower surface of the control plate without protruding from the lower surface.

20. (withdrawn) The boiling cooler according to claim 19, wherein each of the plurality of first communication ports has an opening area larger than an opening area of each of the plurality of second communication ports.

21. (withdrawn) The boiling cooler according to claim 14, wherein the plurality of communication ports are arranged on the control plate at an approximately constant pitch.

22. (previously presented) A cooling system for cooling a heating element, comprising:

a boiling cooler comprising:

a refrigerant vessel storing liquid refrigerant therein, the refrigerant vessel having a boiling portion where the liquid refrigerant boils to produce refrigerant vapor, and defining therein a vapor outflow passage through which the refrigerant vapor flows toward first and second outlet portions provided at opposite ends of the vapor outflow passage;

a first radiator disposed at a first end side of the refrigerant vessel to communicate with the first outlet portion of the vapor outflow passage; and

a second radiator disposed at a second end side of the refrigerant vessel, opposite to the first side, to communicate with the second outlet portion of the vapor outflow passage, wherein:

each of the first and second radiators includes a heat exchange part having a vapor passage in which the refrigerant vapor from the vapor outflow passage flows to perform heat exchange with liquid coolant, and a tank defining a refrigerant chamber that communicates with the refrigerant vessel and stores therein the liquid refrigerant with a liquid surface;

the vapor passage of the heat exchange part is provided above the liquid surface stored in the tank; and

the vapor outflow passage is provided in the refrigerant vessel to extend in a direction crossing with a vertical direction;

a cooling radiator connected to the boiling cooler, for cooling the liquid coolant; and

a motor connected to the boiling cooler in series for supplying the liquid coolant from the radiator to the boiling cooler.

23. (previously presented) The cooling system according to claim 22, wherein the boiling cooler, the first and second radiators, and the motor constitute a liquid coolant circuit in which the liquid coolant circulates.

24. (previously presented) The cooling system according to claim 22, wherein the first radiator cools the liquid coolant by heat exchange with air flowing outside the radiator.

25. (previously presented) The cooling system according to claim 22, further comprising a pipe connecting the first radiator and a coolant passage defined in the boiling cooler in which the liquid coolant flows.

26. (previously presented) The boiling cooler according to claim 1, wherein:

the heat exchange part further comprises a coolant passage in which liquid coolant flows to perform heat exchange with refrigerant vapor in the vapor passage; and

the coolant passage is provided to be separated from outside air outside the heat exchange part.

27. (new) The boiling cooler according to claim 1, wherein the vapor outflow passage is provided to extend approximately horizontally.